LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

ACTUARIAL SCIENCE

MASTER´S FINAL WORK

INTERNSHIP REPORT

INTEREST RATE RISK IN UK DEFINED BENEFIT PENSION SCHEMES

ELENA RENEE MARTEN

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Abstract

Since the financial crisis of 2008, pension schemes began recognizing more than ever that they need to protect against interest rate risk. Interest rate risk is the most significant and volatile risk to pension schemes because a change in market conditions can have a big impact on both the assets and the liabilities of the pension scheme, affecting the funding level of the scheme. De-risking strategies are critical in light of defined benefit pension schemes becoming increasingly unsustainable. Pension schemes are putting many de-risking strategies into place and reevaluating their investment strategies to get to a position to reliably pay their members. This paper discusses how DB pension schemes are affected by interest rate risk, how the risk is reflected in the actuarial valuation report, and what strategies and tools are used to mitigate interest rate risk.

This paper is the result of my five-month curricular internship at Willis Towers Watson. The focus of the internship was UK pension scheme valuations in which I worked with the liability calculations and analysis associated with the actuarial valuation report. The internship gave me the opportunity to apply the actuarial knowledge that I developed in the master to a real work environment. In this paper I show an example of one client who uses de-risking strategies against interest rate risk.

Resumo

Desde a crise financeira de 2008, fundos de pensões começaram a reconhecer, mais do que nunca, a necessidade de se protegerem contra o risco da taxa de juro. Este risco é o mais significativo e volátil para os fundos de pensões pois uma mudança nas condições do mercado pode ter um grande impacto tanto nos ativos como nos passivos do fundo, afetando o seu nível de financiamento. Estratégias de remoção do risco são críticas à luz dos planos de benefícios definidos (BD) estarem cada vez mais insustentáveis. Fundos de pensões estão a considerar várias estratégias de remoção do risco e a reavaliar as suas estratégias de investimento com o objetivo de garantirem, com elevado nível de confiança, os pagamentos aos seus participantes e beneficiários. Este relatório irá discutir como é que planos BD são afetados pelo risco da taxa de juro, como é que esse risco é refletido no relatório da avaliação e que estratégias e ferramentas são usadas para mitigar este risco.

Este relatório é o resultado de um de um estágio de cinco meses na Willis Towers Watson. O foco do estágio foi em avaliações de fundos de pensões do Reino Unido em que eu trabalhei nos cálculos do passivo e na análise dos resultados apresentados no relatório da avaliação. O estágio providenciou-me a oportunidade de aplicar o conhecimento atuarial que desenvolvi durante o Mestrado num ambiente empresarial. Neste relatório, apresento um exemplo real de um fundo de pensões que usa estratégias para remoção do risco da taxa de juro.

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1 Introduction

1.1 Background and Objective

Globally, post-retirement benefits are becoming increasingly more relevant in society as many countries continue to implement pension reforms to tackle the global pension crisis. In the United Kingdom (UK), pension assets of defined benefit (DB) pension schemes exceed £1.6 trillion and most pension funds are underfunded, implying that the value of assets underestimates the value of the liabilities. (Pension Protection Fund Purple Book 2018)

Figure 1: Assets and liabilities of defined benefit pension schemes, s179 basis, £billions. *Source: PPF 7800 index*

As seen in Figure 1 above, overall liabilities of DB pension schemes valued on an s179 basis have been exceeding overall assets since mid-2011. S179 refers to Section 179 of the Pensions Act 2004 which requires schemes to estimate the funding needed to secure Pension Protection Fund (PPF) compensation levels. The PPF was set up by the UK Government to protect the benefits of its members by paying plan members compensation in the case that an employer goes out of business. (The Pensions Advisory Service 2019)

Nowadays in the UK, new DB schemes are rarely established in the private sector and over the past twenty years or so, they are declining as a feature of occupational pensions with most employers making the switch from DB to defined contribution (DC) schemes. Most existing DB schemes are closed to new members and many have frozen, meaning there is no future accrual of benefits upon a certain date. (PPF Purple Book 2018)

Year	Percentage of Schemes			
	Open	Closed to new members	Closed to new benefit accrual	Winding up
2006	43%	44%	12%	1%
2007	36%	45%	16%	2%
2008	31%	50%	17%	2%
2009	27%	52%	19%	2%
2010	18%	58%	21%	2%
2011	16%	58%	24%	2%
2012	14%	57%	26%	2%
2013	14%	54%	30%	2%
2014	13%	53%	32%	2%
2015	13%	51%	35%	2%
2016	13%	50%	35%	2%
2017	12%	47%	39%	2%
2018	12%	46%	41%	1%

Table 1: Distribution of defined benefit schemes by scheme status and year, measured by percentage of pension schemes. *Source: PPF Purple Book 2018*

Table 1 shows that although the statistics are relatively similar from 2017 to 2018, the percentage of open DB pension schemes in the UK has decreased significantly over the years since 2006. The broadly consistent statistics surrounding the percentage of schemes closed to new members can be explained by the fact that so many schemes have closed altogether.

Based on a survey by WTW (2018), DB schemes continue to close expeditiously. Almost one-fifth of DB schemes that are closed to future accrual, closed in the last two years and we can expect more closings over the next three years as seen in Figure 2 below:

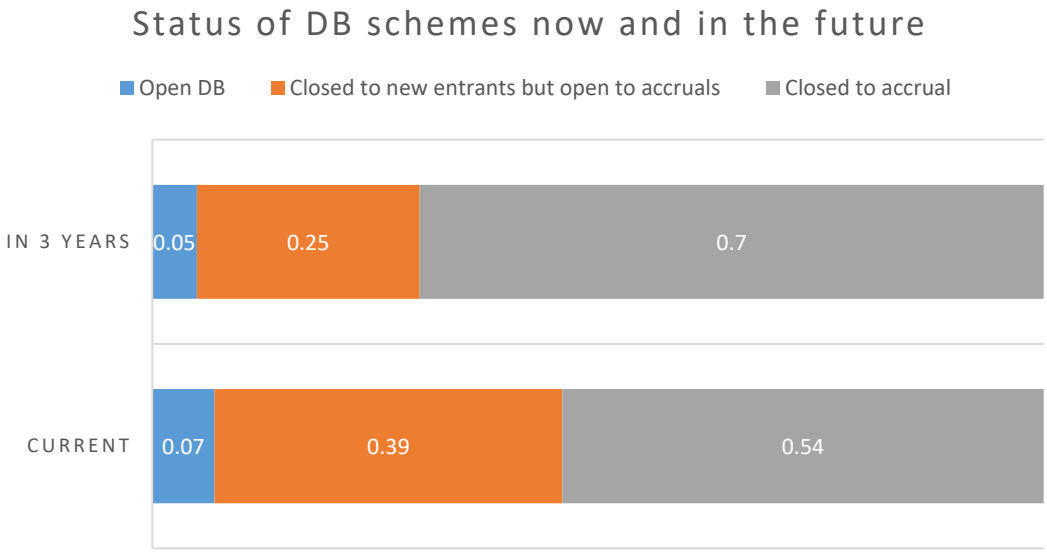


Figure 2: Status of DB schemes now and three years in the future. *Source: WTW UK Pension Strategy Survey (2018)*

Although more and more plans continue to close, 10.5 million members continue to rely on private DB pensions. The DB sector remains an integral part of the UK economy. DB schemes help fuel the economy through investment in UK government bonds, corporate bonds, and equities. (Department for Work & Pensions 2018)

The main strategic objective for many trustees is getting a pension scheme to a position where it can reliably pay its members. The path to reach this objective can be complex and there are several risks involved, but it can be done with careful planning. For this reason, mitigating the risks of pension schemes has come to be known as "de-risking". One of the most significant and volatile risks to pension funds is interest rate risk. Mitigating this risk is crucial for all pension schemes to reach financial independence, as a small change in market conditions can result in significant additional contributions being required.

The UK is the global leader in pension de-risking. From 2007 to 2018, there has been risk transfer of more than £160 billion, including buy-ins, buy-outs and longevity swaps (PPF Purple Book 2018). There is no "one size fits all" prescribed strategy to de-risk a pension fund and most strategies are composed of several tactics. This paper will comment on strategies specifically geared toward de-risking investment risk and discuss the impact of interest rate risk on the actuarial valuation report.

1.2 Internship at Willis Towers Watson

This paper is the product of a five-month curricular internship at Willis Towers Watson (WTW), Lisbon Service Center (LSC). The focus of the internship was to work in actuarial valuations of UK defined benefit pension plans. WTW is a global leader in risk management and the LSC provides specialist services in pension data to clients in several countries.

The curricular internship provided extensive training in the use of WTW's software, pension valuations, and UK-specific pension rules and regulations. The internship provided the opportunity to perform a practical application of the knowledge developed through the Master of Actuarial Science at ISEG.

1.3 Structure of Report

This report will begin by introducing the issue of interest rate risk that is impacting DB pension schemes, beginning with the financial crisis of 2008 until today. I will discuss DB pension schemes in more detail, in particular, how they are affected by interest rate risk and how the risk is reflected in the actuarial valuation report. Then I will discuss what is being done by DB schemes to mitigate interest rate risk. I will comment on several common strategies that schemes use and finally introduce an example of a WTW client that has implemented de-risking strategies.

1.4 Literature Review

De-risking DB pension schemes has been a hot topic in retirement consulting services over the last decade. I became aware of this matter prior to entering my internship at WTW, curious about the role of the Actuary in the de-risking process.

The first thing that I felt the need to research were the main drivers of risk. Many articles I read focused on the three main drivers of risk: interest rates, inflation, and longevity. For example, *The Pension Risk Transfer Market at $260 Billion* from Amy Kessler, William McCloskey, CFA, and Arnaud Bensoussan of Prudential. One resource that provided a global perspective on DB pension schemes was from OECD (2017) entitled *Pensions at a Glance.* I also read articles about less obvious drivers of risk such as *War and Pensions* by John A. Turner (2016) which showed me a driver of risk that I never even considered, teaching me that war has heavily influenced pension funds all over the world.

To learn more details about the financial crisis of 2008 I turned to YouTube. I found that videos from History (2018)[1] and Crash Course Economics (2015)[2] provided excellent brief overviews of the complicated situation that was the financial crisis.

One article from Kenneth F. Hohman (2014), entitled *Risk Transfers: the Other Side of De-risking* opened my eyes to the concept that "de-risking" is not exactly an accurate term for the fact that it is actually impossible to eliminate the risk altogether, but rather the risk is transferred, pooled, or shared. This opens endless opportunity for risk management strategies.

What I would consider my most valuable resources came from the UK Government. The Pension Protection Fund (PPF) was established in the UK to protect DB pension plan members in the case of insolvency of the pension fund. The PPF provides a document called the *Purple Book* which presents statistics of DB pension schemes in the UK. The schemes presented in the data are all eligible for PPF funding.

Two papers published by the Department for Work & Pensions are the *White Paper* (2018) and the *Green Paper* (2017). These documents outline the government's intentions for protection and improvement of DB pension schemes in an effort to ensure the protection of plan members and the sustainability of DB pension schemes.

I also had access to many internal resources from WTW such as training materials as well as articles and research published by WTW.

[1] *Here's What Caused the Great Recession,* Youtube: https://youtu.be/yM0uonkloXY
[2] *The 2008 Financial Crisis: Crash Course Economics #12,* Youtube: https://youtu.be/GPOv72Awo68

1.5 Introduction to the Global Pension Crisis

1.5.1 The Financial Crisis of 2008

The financial crisis of 2008 was triggered in the United States (US) by the collapse of the housing bubble. In the early 2000s, the US housing market was booming and recognized as a low risk, high return investment. To make more money, banks started selling mortgage backed securities.

In order to fulfill the high demand of investors, banks and lenders created more supply by lowering their standards to subprime mortgages which are issued to people with low credit ratings, to whom which banks and lenders would historically not have considered loaning to. Thus, subprime mortgages were being issued to people who are less likely to pay them back and because of this high risk, they were also charging them higher interest rates.

Subprime lending practices were new, so investors were seeing mortgage debt falsely labeled as a safe bet by credit rating agencies because the credit rating was based on the minimal historical data that existed at the time. Housing prices were driven higher by low interest rates making the investments even more appealing. Still, mortgage debt was becoming increasingly more risky.

In 2007, the housing bubble burst. Suddenly, demand went down and people stopped investing in real estate. Prices dropped rapidly. People were unable to sell houses and homes were foreclosed so financial institutions and homeowners alike lost money. The housing market failed, banks collapsed, and the economy plummeted. People and businesses started spending less money.

Mortgage-related securities were being traded all over the world causing trillions of dollars in risky mortgages to become embedded in the financial system, so the whole world felt the collapse of the economy during this time.

The effects of the financial crisis on the UK can be seen in Figure 3 where there is a clear decrease in GDP for five successive quarters from April 2008 to July 2009. It took the UK economy five years to return to the size it was before the crisis.

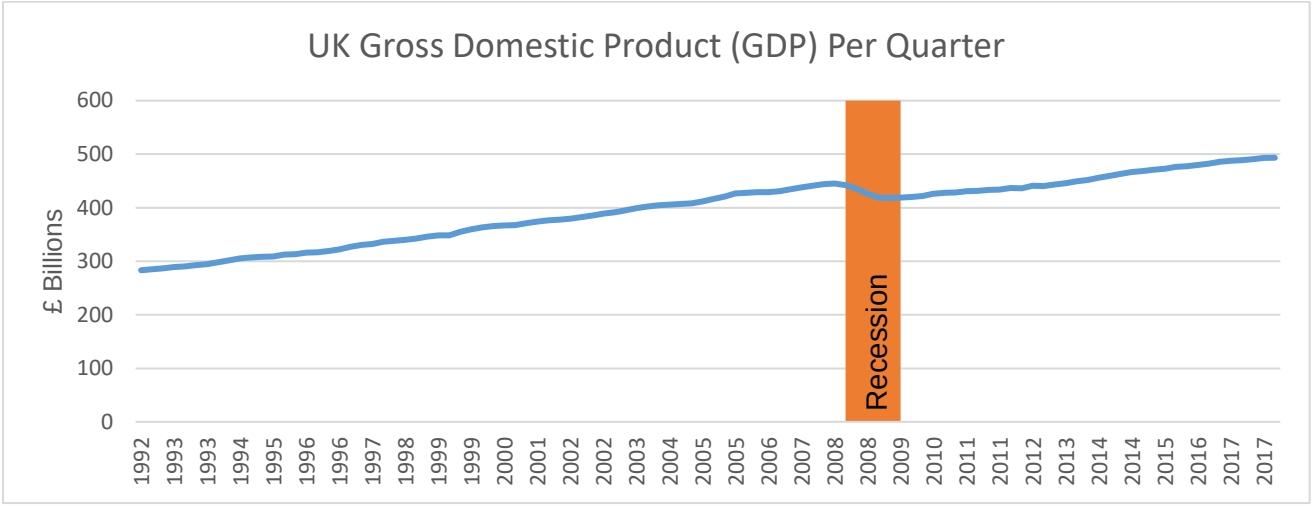


Figure 3: UK gross domestic product (GDP) per quarter. *Source: Office for National Statistice (ONS) (2019)*

1.5.2 The Pension Crisis Today

The financial crisis immediately affected pension fund assets. The severe problem here is that these assets are directly used to pay the DB payouts. The stock market crash caused these assets to be worth less and consequently left many pension plans in deficit.

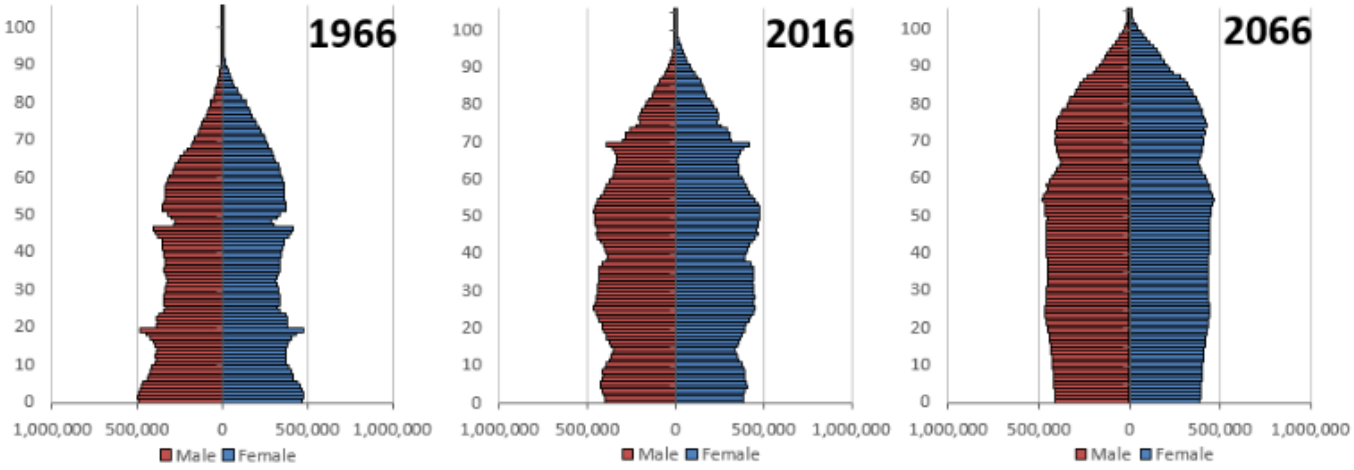


Figure 4: Population estimates, Principal population projections, 2016-based. *Source: ONS (2016)*

It can be seen in Figure 4 that the UK has an aging population. It is projected that by the year 2050, one in four people in the UK will be aged 65 years old and over. (ONS 2016)

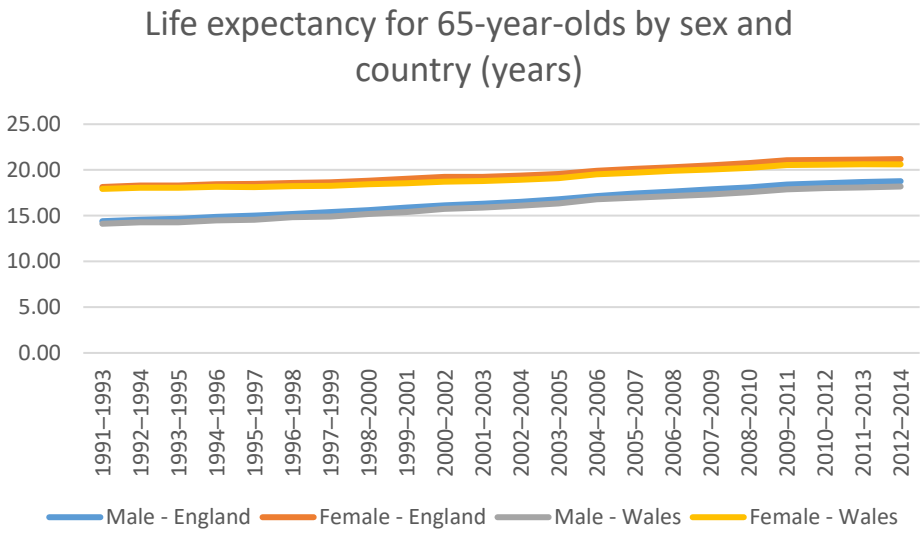


Figure 5: Life expectancy for 65-year-olds by sex and country for England and Wales, 1991-1993 to 2012-2014. *Source: ONS (2015)*

As a repercussion of life expectancy, the demand of pension funds increased and the employers no longer wish to bear the longevity risk. For that reason, most employers are replacing their DB plans with DC plans, in which the pension amount is determined by the contributions into the fund, without knowing in advance what the benefit will be at the time of retirement. This way, their employees will still have access to retirement benefits but it will be the employees that will bear the risk.

As seen in Figure 6, the active membership of private sector occupational DB pension schemes continues to decrease while membership in DC schemes is increasing. The additional increase in DC plans shown in the graph in more recent years can be attributed to an automatic enrollment initiative introduced in the UK in 2012 in which employees were automatically enrolled in a DC plan as a way to encourage saving for retirement.

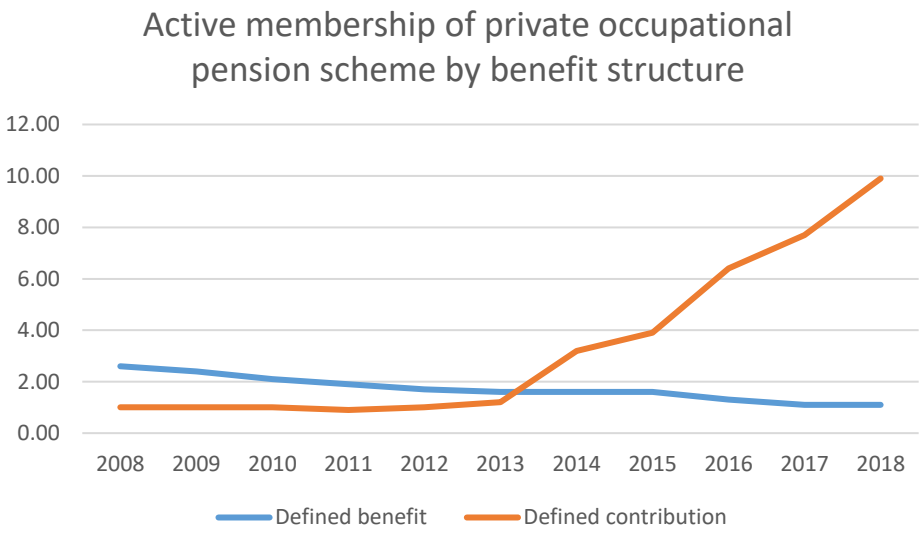


Figure 6: Active membership of private occupational pension scheme by benefit structure, UK, 2008 to 2018. *Source: ONS (2019)*

2 Defined Benefit Pension Scheme

DB schemes are usually occupational pension schemes arranged by the employer providing a guaranteed benefit to members at retirement. The amount received by the pensioner depends on the rules of the pension scheme.

The members of the scheme are promised a specified amount upon their retirement based on a formula that usually depends on their years of service, pensionable salary, age, and accrual. For example,

$$\propto \% \times years\ of\ service\ \times pensionable\ salary. \qquad (1)$$

Where $\propto \%$ represents the accrual rate, or the rate at which the pension plan member builds up the pension benefit. The accrual rate of UK pensions is most commonly equivalent to 1/60th or 1/80th. The years of service are the amount of years that the member is accruing credit as an active member of the pension plan, commonly capped at 40 years of service. The pensionable salary can be calculated in several ways, depending on the rules of the pension scheme. For example, the pensionable salary may be equivalent to the final salary of the member before retirement, the average salary of the member during their active years of service, or another calculation determined by the pension scheme rules.

The employer or plan sponsor is responsible for making contributions to the pension fund to pay for the pension plan members' benefits. Money in the fund is invested in assets which produce additional income to provide the benefits and reduce the contributions required. Funds are then administered by the Trustees according to the rules of the scheme.

The total cost of the pension is unknown at the outset and the employer bears the risk of additional funds being required. Plan sponsors are legally obligated to fulfill these promises in the future regardless of economic or demographic factors that may influence their funding level before the date of payment. This has become a difficult task for plan sponsors as most pension schemes are underfunded. Actuarial valuations are a vital tool to assist the plan sponsors in understanding their financial position.

2.1 Actuarial Valuation

It is the job of the actuary to perform an actuarial valuation which puts a current value on the liabilities of a defined benefit scheme. To do this, the actuary must consider the population data available, the rules of the pension plan scheme, and to set the required assumptions.

As an Actuarial Analyst Intern at WTW, I worked on several steps of the actuarial valuation, working closely with my colleagues in the consulting offices (CO) throughout the UK. The CO would provide the data and assumptions. I would check the data for consistency and accuracy. Then I would apply the assumptions to the valuation and analyze the results.

2.1.1 Valuation Assumptions

The main assumptions used in the actuarial valuation can be divided into two categories: economic assumptions and demographic assumptions.

Economic assumptions:

- Inflation
- Discount rate
- Earnings increases
- Pension increases
- Pension revaluation

Demographic assumptions:

- Mortality (i.e. life expectancy)
- Withdrawal from the scheme
- Normal retirement age
- Early retirement
- Ill health/disability
- Spouses (age/existence)
- New entrants to the scheme

The main assumption associated with interest rate risk is the assumption for the discount rate, which will be discussed in more detail in the next chapter.

After a specific period of time, usually three years, an actuarial valuation will be performed and the actuarial assumptions will not exactly match the actual experience, and from this mismatch will result what is called an actuarial gain or an actuarial loss. When the actual experience reduces, or increases, the value of the liabilities when compared to the expected then an actuarial gain, or loss, will be presented respectively.

2.1.2 Purpose of the Actuarial Valuation

The actuary will perform the valuation with different bases for different purposes. The funding position of a pension scheme can be different depending on the purpose of the valuation and the assumptions used for the calculation. There are five main funding approaches (The Pensions Regulator 2018):

1. **Statutory Funding Objective (SFO):** The purpose of the statutory funding objective is to determine if the fund has substantial assets to cover their liabilities. The strategy generally assumes higher discount rates because a higher proportion of return-seeking assets are considered, leading to lower liabilities.
2. **PPF buy-out/section 179 basis:** The Pension Protection Fund (PPF) was established to pay compensation to members of eligible DB pension schemes when the plan sponsor becomes insolvent. According to section 179 of the Pensions Act 2004, schemes must estimate the required funding to secure PPF compensation levels. The assumptions used for a PPF valuation are standard across all schemes.
3. **Self Sufficiency:** When a pension scheme reaches a "self-sufficiency level" of assets, it is expected to be able to sustain itself by investing those assets on a low risk basis.
4. **Insurance Buy-Out:** This valuation determines how much money the scheme would need to buy all the accrued benefits from an insurance company. Few schemes can immediately proceed with a buy-out. Many employ a de-risking strategy over time while moving towards buy-out.
5. **Accounting:** Sponsoring employees are required to use the accounting valuation for the purpose of publishing in their annual report and accounts. The assumptions used for the accounting basis are the relevant accounting standards.

Pension funds regularly commission actuarial valuations – legally required at least once every three years – to determine if the scheme is appropriately funded. In the case that a scheme does not meet the statutory funding objective, a recovery plan must be put in place.

2.2 Pension Liabilities

Pension liabilities are the value of the financial obligations of the plan sponsor which are represented by the pension entitlements of the scheme members that accumulate over time. Pension scheme liabilities are expressed in terms of present value. This is the value of the amount now, which after being invested over the

time until retirement benefit payouts are to be made, is expected to be adequate to cover the payout of the pensions promised. Present values are used in order to consider the time value of money.

Essentially, the pension liabilities are calculated by projecting forward all future cash flows (pension payments) and then discounting them back to the effective valuation date, using actuarial assumptions that are chosen prudently. This can be represented by the example of the following formula for the present value of future benefits for a single pension plan member who is below the normal retirement age:

$$PVFB_{VA} = benefit_{NRA} \times a_{\ NRA} \times {}_{NRA-VA}p_{VA} \times v^{NRA-VA}; \qquad (2)$$

Where

$PVFB_{VA}$ is the present value of future benefits at the effective valuation date;

$benefit_{NRA}$ is the annual benefit to be obtained by the member at the normal retirement date;

$a_{\ NRA}$ is the present value of the annuity that the member will receive at the normal retirement age

${}_{NRA-VA}p_{VA}$ is the probability of the member remaining a plan member in good health from the effective date of the valuation until the normal retirement age;

And v^{NRA-VA} is the discount factor for the years between the effective date of the valuation and the normal retirement age.

In other words, consider the calculation of the liability of a single active member. First, the amount of each pension payment that the member will receive in the future is calculated. The pension payment amounts are multiplied by the probability that the member will remain a plan member and in good health at the time of payment. Then each payment is discounted back to the effective date of the valuation. Finally, all the discounted amounts are summed. This gives the liability of the single active member. Summing the liabilities of each individual member will then give the liability of the whole pension plan.

2.3 Interest Rate

Discount rates are the heart of actuarial calculations, but before we can understand discount rates, it is first important to understand interest rates. In the UK, the central bank base rate[3] is set in order to meet the target that the Government sets us to keep inflation low and stable.

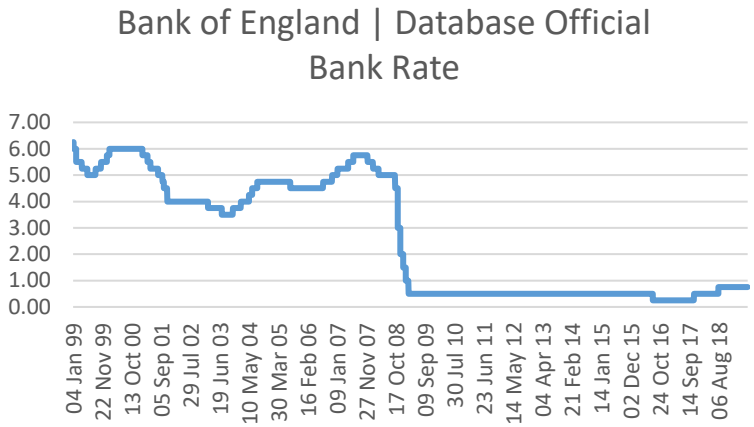


Figure 7: Interest rates in the U.K. for the past 20 years. *Source: Bank of England (2019)*

As seen in Figure 7, central bank interest rates plummeted in 2008 following the global financial crisis. Prior to the financial crisis, the central bank base interest rates fluctuated between 3.5% and 6%. Interest rates were at 5% when the financial crisis broke out in 2008.

The long-term interest rates in the UK are usually measured by gilt or swap yields. Gilts and swaps are two financial products that will be discussed in more detail in Chapter 3. The yield curves of these financial products are derived individually from the full maturity spectrum of each respective financial product.

[3] Central bank base rate it is the interest rate that the Bank of England pays to commercial banks that hold money with them. It influences the rates those banks charge people to borrow money or pay on their savings.

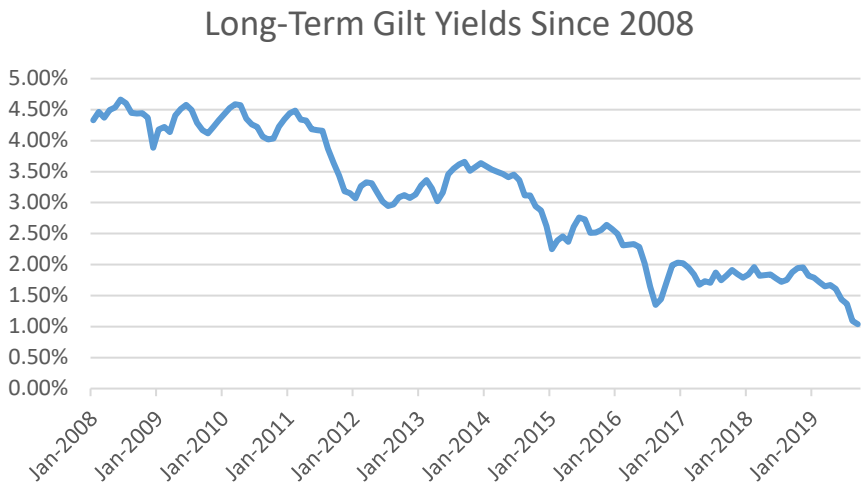


Figure 8: Long-term gilt yields (20-year) since 2008. *Source: United Kingdom Debt Management Office (2019)*

Since the financial crisis, interest rates have fallen multiple times and in 2019, the nearly 1% fall has brought us historically low interest rates. This will increase deficits in schemes that are not fully hedged. For example, a scheme that is 90% funded and 80% hedged, the deficit will have increased by over 50% in 2019. Funds that are fully hedged may show unexpected gains or losses due to the magnitude of the fall. (XPS Pensions Group 2019)

2.3.1 Discount Rate

As the majority of benefits in a pension scheme are paid many years in the future, the Trustees invest the pension funds during the period before the benefits are paid in order to achieve a return on those funds. In the calculations of liabilities and contributions required, it is appropriate to allow for the expected interest rate. This is done by discounting the future pension payments to the valuation date.

The discount rate is closely related to the interest rate. The following table displays the relationship between interest rates and discount rates:

	Effective Rate of Discount	Effective Rate of Interest
Measures	Growth on the basis of the initially invested amount	Growth on the basis of the year-end accumulated amount
General Formula	$d = \frac{i}{1+i}$	$i = \frac{d}{1-d}$
Present Value Form	$v^n = (1-d)^n$	$v^n = \frac{1}{(1+i)^n}$
	$d = iv$	

Where

d is the discount rate;

i is the interest rate;

v is the discount factor;

n is the number of years.

The discount rate is a key component in determining the technical provisions of the pension fund. Many factors influence the chosen discount rate and there is no single way of determining this rate. For funding purposes it is usually determined based on how the Trustees choose to invest the assets of the pension fund, taking into account the level of risk they are willing to take based on the support the fund can expect from the employer in the event that the investments fail to deliver.

According to the Code of Practice (The Pensions Regulator 2014), "Discount rates used in setting technical provisions must be chosen prudently, taking into account either:

- The yield on assets held by the scheme to fund future benefits and the anticipated future investment returns; and/or
- The market redemption yields on government or high quality bonds."

In the actuarial valuation, it is common to find separate discount rate assumptions for the pre-retirement period and the post-retirement period. This is because the duration of the liabilities is different for active participants

and for retired members as schemes generally hold a higher proportion of return seeking assets for non-pensioners and more matching assets when it comes to retired members.

In some cases, rather than considering a fixed discount rate, the actuary will recommend the use of a full spot-rate yield curve for discounting projected benefit cash flows.

2.4 Funding level

The funding level is the present value of the accrued liabilities compared with the current value of the pension plan's assets. This identifies the amount of surplus or deficit and is expressed as a percentage of the value of the assets divided by the value of the liabilities.

A 100% funding level would suggest that a scheme has the ability to support future accrued benefits for employees. Most DB pension schemes in the UK are underfunded, meaning their funding level is below 100% and their current financial position will not allow for the support of future accrued benefits of employees. Hence, most companies are moving away from DB pension schemes.

A decrease in interest rates will cause liabilities to increase because the lower interest rate will be reflected in a lower discount rate implying higher liabilities. Assets will decrease due to a decrease in asset returns. Thus, the decrease in interest rates will be expected to decrease the funding level of a scheme.

3 Interest Rate Risk

The Trustees are responsible for determining the investment strategy of a pension scheme having consulted the employer and after taking advice from their investment consultant. The Trustees delegate day-to-day management of the investments to appointed and authorized investment managers. The Trustees agree to a statement of investment principles (SIP) which is reviewed annually for appropriateness. This document sets out the policy for investing the Fund's assets.

The objective of the DB section of a scheme is to maintain a portfolio of suitable assets that will generate income and capital growth that, along with new contributions, will meet the commitment of the benefits payable to plan members. The pension scheme is subject to some potentially material risks that may affect the funding level of the scheme. These risks are, to an extent, outside of the Trustee's control.

The EIOPA Financial Stability Report (2019) has identified interest rate risk as the most significant risk to pension funds. It is important for funds to protect against interest rate risk because of how sensitive the liabilities of the pension fund are to fluctuations in long-term interest rates.

The low interest rate environment after the financial crisis affects pension funds in both the assets and liabilities. Low interest rates cause the liabilities to increase. If the discount rate used in an actuarial valuation is based on long-term interest rates, protracted low interest rates imply a higher ongoing level of liabilities. The longer the duration of the liabilities, the greater the impact. Assets are affected by the reduction in future asset returns.

The liabilities of pension funds tend to have high durations and it is not easy to find in the market long term assets with the same duration as the pension liabilities, making it likely for pension funds to present a negative duration gap. The high demand for long duration bonds to match the long duration of the assets create further downward pressure on market bond yields. This implies that low discount rates boost the value of the liabilities to a greater extent than the value of the assets.

3.1 Managing Interest Rate Risk

3.1.1 De-Risking

"De-risking" is the term being used in the pensions industry referring to the management of pensions-related volatility on companies and government balance sheets and expenses. The goal is to achieve a lower-risk future while fulfilling the lifetime benefit promises to all plan participants.

Managing pension-related risk has become critical for the survival of pension funds while tackling the global pension crisis. Post World War II, pensions were viewed more from a human resources perspective, providing long-term benefits to employees in exchange for their long-term dedication to a company or organization. Nowadays this perspective has refocused from human resources to the CFO[4] amidst companies assuming significant market and interest rate risk. This has caused companies' outlook on pensions to be more financially driven. (Hohman 2014)

There are several strategies being used in the U.K. to de-risk defined benefit pension schemes. Some common strategies to de-risk on the obligations side are freezing the plan, offering lump sum buyouts, purchasing bulk annuities, and liability driven investing (LDI). The latter of these examples is the primary strategy used to tackle the pension fund investment risk and interest rate risk.

De-risking strategies generally transfer risk from one party to another, usually from the employers to the employees or society. LDI strategies exchange one risk for another but the risk remains in the employer's domain, making it relatively noncontroversial in regards to who is taking on the risk.

3.1.2 Journey Plan

Private defined benefit pension schemes that choose to de-risk put into place a long-term journey plan. This is a plan over a specified period to mitigate risks until the final endgame of terminating the plan. Oftentimes journey plans involve a combination of strategies to de-risk the pension scheme, one common strategy being liability driven investing.

At the Willis Towers Watson Pensions and Savings Conference 2018, long-term journey planning was at the top of the list of most important issues impacting pension schemes over the next three years. In a survey of over 150 DB schemes in the UK, most schemes said they have a long-term journey plan. Only one third of schemes said they do not have a journey plan, and of that third, two-thirds have one in development, leaving only 14% with no plan in place or in development. (WTW 2018a)

According to the UK Government White Paper (2018), *Protecting Defined Benefit Pension Schemes*, schemes that are drifting without a plan will need to make changes. It is crucial that the trustees and the employers come up with a journey plan together to make sure long-term objectives are met, especially as pension schemes are

[4] CFO - Chief Financial Officer

maturing. For example, an appropriate long-term objective for a mature closed scheme might be to secure members benefits through buy-out within a specified period of time.

3.1.3 Common De-Risking Strategies

There are many strategies to de-risk interest rate risks from pension schemes and most schemes use a combination of de-risking strategies. This section will briefly discuss some of the most common strategies that are used to de-risk interest rates in pension schemes.

3.1.3.1 Moving from DB schemes to DC schemes

Changing the plan from DB to DC shifts the predominant risk from the employer to the pension plan participant. Defined contribution pension assets now equal those of defined benefit plans and very few companies -if any- now starts a fully defined benefit scheme. In order to protect vested benefits, this path often gives rise to hybrid/mix schemes.

3.1.3.2 Freezing the pension plan

Most existing defined benefit schemes in the US and the UK are closed to new members and many are frozen. Frozen defined benefit schemes include “soft” freezes in which the plan is closed to new accrual and “hard” freezes where in addition to the plan being closed to new accrual, future increases in participant earnings are not considered in the benefit formula. Closing the scheme to future accruals is one of the most effective procedures for a plan to limit the growth of liabilities which in turn, protects against risk.

3.1.3.3 Purchasing bulk annuities

The purchasing of bulk annuities is considered risk transfer because there is a shift in risk from the plan sponsor to a third party by a contractual agreement. The UK is the global leader in Pension transfers to insurance companies and more countries continue to follow their lead. Since 2007, more than $430 billion in pension liabilities have been transferred globally. Pension de-risking is customizable to corporations big and small across all industries. The goal is to achieve a lower-risk for the company while fulfilling the lifetime benefit promises to all plan participants. (Prudential 2019)

This certainly comes at a price, as the insurance company determines the premium it will require to assume the risk. In the current low interest rate environment, and due to fundamental differences in pension plans and insurance regulation -namely Solvency-, the purchase of annuities from an insurance company still seems very expensive. In the case of an annuity buy-out, all risk is transferred from the plan sponsor to the insurer.

3.1.3.4 Offering lump sum buyouts

Many companies, where permitted, may offer lump sum benefits to plan participants as a risk-transfer strategy. With this measure, the risk is transferred from the plan sponsor to the plan participant. Oftentimes, the plan participant may not have a firm understanding of the risks they are assuming in a lump sum buyout and for this reason it is important for the details of the lump sum offer to be explained to the plan participant in a transparent way for all parties involved to have a clear understanding.

3.1.3.5 Liability Driven Investing

Liability driven investing (LDI) refers to the investment strategy of investing in assets whose value moves in the same way as the liabilities. This way the trustees protect the pension fund against unrewarded risks and stabilize funding levels. The objective is to mitigate the risk of failing to meet obligations because of changes in the market value of assets.

Pension funds can have a higher sensitivity to interest rates due to a mismatch in duration between assets and liabilities. Duration is a measure of the years required to pay back the price of a bond by the bond's total cash flows.

If assets and liabilities are not well matched, a change in market conditions (such as a fall in interest rates) affects assets and liabilities differently, potentially giving rise to deficit.

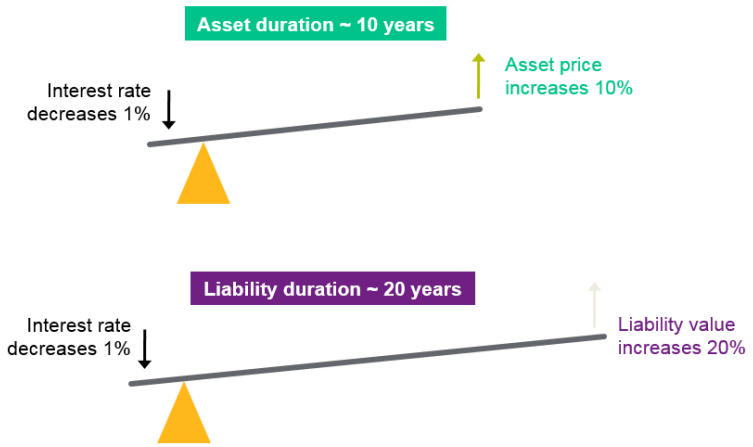


Figure 9: Comparison of how a 1% decrease in interest rates will affect assets versus liabilities. *Source: WTW internal*

Liability hedging aims to reduce the risks in a pension scheme, assuring that any increase on the liability side will be compensated by an increase on the fund's value.

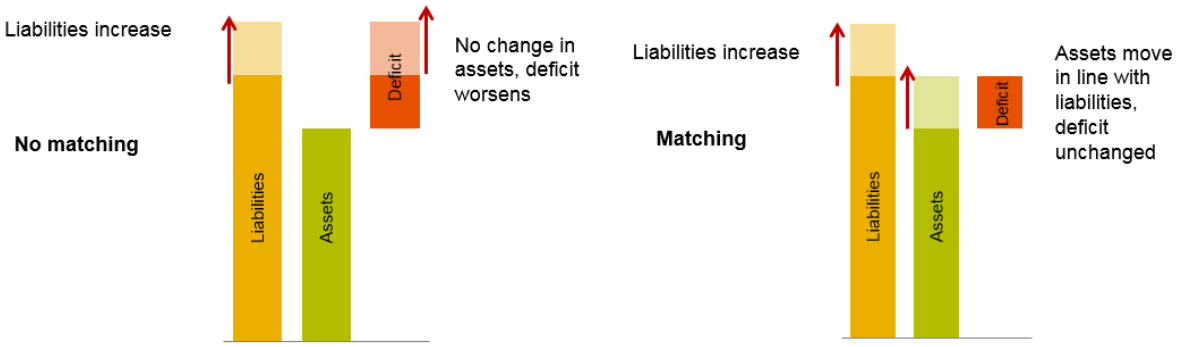


Figure 10: Comparison of how liability matching will impact the deficit. *Source: WTW internal*

Better matched assets and liabilities will respond to changes in the relevant financial valuation drivers.

Aon produced an analysis that determined that closed and frozen schemes are hedging approximately 30 to 40 percent of their interest rate risk, but suggest that these schemes should actually be protecting against at least 70 percent. The hedging ratio is a measure of the value of the liabilities protected by the use of a hedge compared to the total liabilities. Making changes to the scheme's investment strategy is likely to be worthwhile for the additional return and protection against future market movements. (Aon 2014)

So what is preventing all pension schemes from adopting an LDI investment strategies to protect against interest rate risk? There are several barriers to hedging interest rate risk. The main barriers include the low interest rate environment and access to the appropriate financial tools to produce an LDI.

3.1.3.5.1 FINANCIAL PRODUCTS FOR LIABILITY DRIVEN INVESTING

The main assets used in the LDI strategy are swaps and bonds because they experience the same changes in value as pension liabilities with fluctuations in interest rates and inflation change. I will focus only on LDI against interest rate risk.

3.1.3.5.2 BONDS

Bonds are essentially a loan made to an investor by a borrower who is often corporate or governmental. Changes in interest rates affect bonds in the same way that they affect pension scheme liabilities. A fall in interest rates will increase the present value of the pension scheme liabilities and the bond will also increase in value, as the future cash flows are being discounted at a lower rate.

The overall percentage of UK pension scheme assets invested in bonds has increased from 28% in 2006 to 59% in 2018, confirming the increased need for LDI strategies in order to mitigate the interest rate risk that the pension funds are facing. (PPF Purple Book 2018)

3.1.3.5.2.1 GOVERNMENT BONDS (GILTS)

Gilts are debt issued by the UK government which are considered low risk due to the financial security of the UK government, however these bonds may be scarce because the distribution of gilts is dependent on the UK government's need to raise capital. Thus, supply is unpredictable.

3.1.3.5.2.2 CORPORATE BONDS

Corporate bonds are debt issued by companies. They are considered riskier than government bonds because they are issued by companies that are generally less financially secure than the UK government. The additional risk comes from the fact that corporate bonds add credit risk.

3.1.3.5.3 SWAPS

Swaps are a derivative contract in which two parties exchange cash flows. The most common swaps are interest rate swaps in which two parties exchange interest payments on underlying debt. A pension scheme may use an interest rate swap to receive bond-like returns by receiving a fixed rate of interest from a bank. Swaps can target different liability profiles.

Swaps are growing in popularity as an LDI tool as they are more flexible and more available than bonds. Unlike bonds, swaps are not restricted by physical supply and they are also available over virtually any maturity up to 50 years.

3.1.4 Barriers to Mitigating Investment Risk

3.1.4.1 Low Interest Rate Environment

All parts of the world felt the collapse of financial markets in 2008 that resulted in severe economic downturn in the following years.

In the past, plan sponsors were taking on significant equity risk. This ultimately hurt the company during times in which the equity markets performed poorly, for instance the financial crisis of 2008. It has become evident that there is a need for managing pension-related risk in order to protect against shocks in the economy, especially in the context of the current political and economic uncertainty in the UK.

Thanks to the financial crisis, people were limiting their spending and many people were left without jobs. This led to interest rates being cut to really low levels to stimulate growth and prevent inflation. The low interest rate environment has been necessary while economies recover because interest rates affect investment performance which in turn impacts how people save and build their retirement savings. Recently things have been changing and interest rates have risen slightly. (Bank of England 2019b)

There has been a popular theory argued for a long time that since interest rates are at historic lows, trustees can wait for them to rise. More recently, funds are recognizing that hedging interest rate risk should be a priority irrespective of the interest rates level. Had pension funds made this realization 20 years ago maybe there would be less of a global pension crisis.

3.1.4.2 Accessibility of Financial Tools

Since UK pension funds began to incorporate LDI in the last decade, DB pension fund liabilities have steadily risen and hedging instruments have become more expensive. The LDI market is growing remarkably. As it is growing, the question becomes, will supply match demand? The UK government has been striving for a budget surplus by the year 2020, thus reducing gilt issuance. This will not stop pension funds from applying LDI strategies, but prices will be driven upward by demand.

4 Practical Analysis

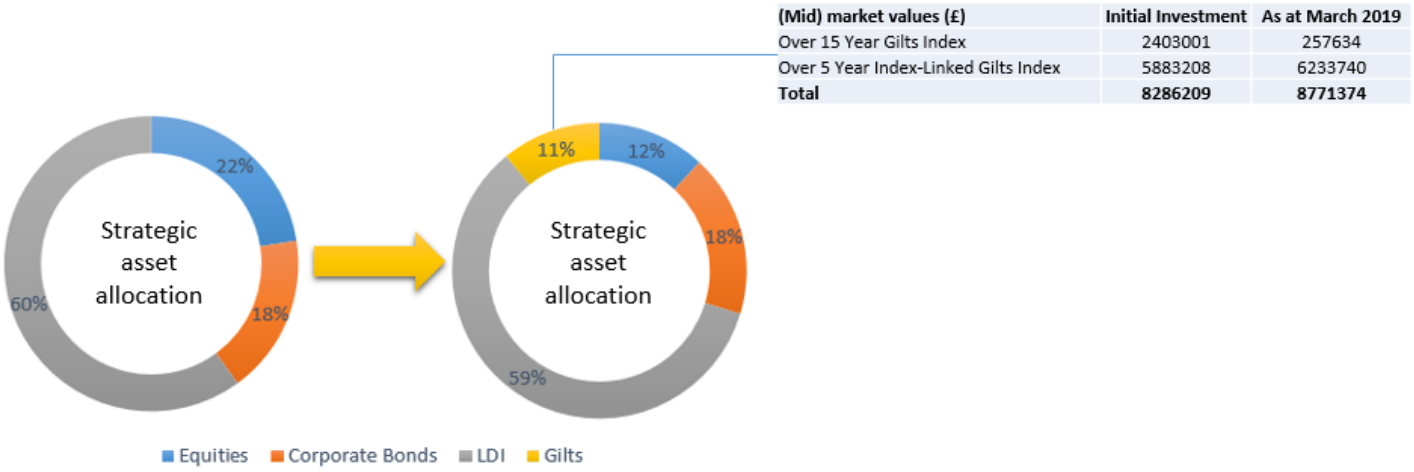
In this section we will look at an example of a scheme that has implemented an LDI strategy in March 2018. An LDI manager is responsible for designing the Scheme's current LDI strategy. The LDI strategy is based on liability cash flows from the March 2015 actuarial valuation and involves investing in leveraged gilts and swaps alongside traditional gilts to give the desired degree of leverage and hence hedge ratio. The LDI strategy targeted a hedge ratio of 87% for interest rates.

A summary of the strategy is set out below:

(Mid) market values (£)	Initial Investment As at March 2018	As at March 2019
Aquila Life Over 25 Years UK Index Linked Gilt Fund	15,161,652	16,398,128
Aquila Life Over 15 Years UK Gilt Index Fund	5,495,813	5,855,021
LMF GBP REAL 2020-2024 SWAP FLEX	700,000	780,826
LMF GBP 2027 IL GILT FLEX	1,400,000	1,778,588
LMF GBP 2032 IL GILT FLEX	2,100,000	2,635,596
LMF GBP 2040 IL GILT FLEX	3,300,000	4,004,007
LMF GBP 2050 IL GILT FLEX	600,000	722,160
LMF GBP 2068 IL GILT FLEX	1,200,000	3,052,587
LMF GBP 2060 GILT FLEX	2,600,000	1,407,607
LMF GBP 2068 GILT FLEX	800,000	966,781
Institutional Sterling Liquidity Fund (ICS)	10,405,956	8,698,279
Total	**43,763,421**	**46,299,580**

Table 2: Scheme investment strategy. *Source: WTW internal Scheme SIP*

In August 2018, the Trustees chose to reduce risk in the Scheme's investment strategy by reducing the allocation to equities from 22.5% to 12%, and moving these assets into government bond funds.



(Mid) market values (£)	Initial Investment	As at March 2019
Over 15 Year Gilts Index	2403001	257634
Over 5 Year Index-Linked Gilts Index	5883208	6233740
Total	**8286209**	**8771374**

Figure 11: Movement of scheme strategic asset allocation. *Source: WTW internal*

Introducing this additional allocation to gilts increased the Scheme's hedge ratios. In July 2018, it was estimated that the switch would increase the hedge ratios of interest rates to 99%. If, as expected, the interim gilts allocation is moved into non-liability matching assets, then this additional hedging will be removed.

Figure 12 below compares the projected future cashflows based on the 2015 and 2018 actuarial valuations.

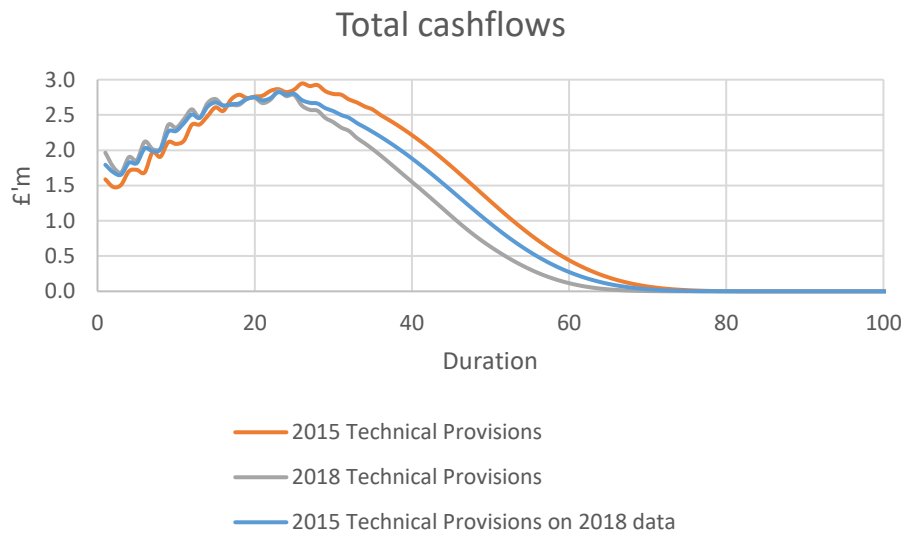


Figure 12: Projected total future cashflows based on the 2015 and 2018 actuarial valuations and the 2018 data with 2015 assumptions. *Source: WTW internal*

This chart suggests that the fundamental shape of the projected cashflows has not materially changed between the two valuations, and so the overall structure of the LDI portfolio is likely to remain broadly appropriate. However, there has been a slight reduction in the overall duration of the cashflows in moving from the 2015 valuation to the 2018 valuation, of around 1.5 years.

PV01 is a measure of the portfolio's sensitivity to changes in interest rates. It represents the change in the present value of the liabilities for a 0.01% change in the relevant interest rate curve. These values can be seen in the table below.

31 March 2018	Liabilities	Assets	Hedge Ratio
PV01	145,000	159,000	110%
Duration	20	21	

Table 3: Scheme PV01 data. *Source: WTW internal*

The PV01 of the liabilities is the change in liabilities resulting from a 0.01% upward shift in the yield curve used for the discount rate assumption. The PV01 of the asset portfolio is sensitivity of the total scheme assets to a 0.01% change in interest rates. In this Scheme, the spot curve is used for the interest rate calculation.

The 2018 Scheme valuation was based on an updated membership data and updated mortality assumptions. This served to reduce the duration of the liabilities slightly, meaning that the liability values are less sensitive to changes in interest rates. Because of this, it is estimated that the hedge ratios have increased. This has been magnified by the improvements in the Scheme's funding levels. This has led to the Scheme being over-hedged with respect to interest rate changes.

After making an approximate allowance for the interim investment in gilt funds, which was made after the effective actuarial valuation date in 2018, the hedge ratio increases are exaggerated. If, as expected, the interim gilts allocation is moved into non-liability matching assets, then this additional hedging effect will be removed.

31 March 2018 (allowing for interim gilts allocation)	Liabilities	Assets	Hedge Ratio
PV01	145,000	180,000	124%
Duration	20	24	

Table 4: Scheme PV01 data allowing for interim gilts allocation. *Source: WTW internal*

The interim allocation to gilts has increased the degree of over-hedging, but this will be reversed if the Trustees opt to replace these holdings with non-liability matching assets.

With this information, WTW would recommend to the Scheme that the interim gilts allocation is replaced to reduce the degree of over-hedging in the short term. Because the LDI portfolio remains broadly consistent, it would be recommended that the LDI portfolio is kept unchanged until the Trustees have completed or decided against, the potential buy-in. The Trustees should then conduct a full review of the design of the LDI portfolio, in order to ensure that the assets remain closely matched to the liabilities and the Scheme is not over-hedged.

Now that we know how both the assets and the liabilities will be influenced if the interest rate changes by 1 basis point, ceteris paribus, we have an idea of how the scheme can be affected by interest rates in the future, however for the purpose of the actuarial valuation, we must also make an assumption about the interest rate to value the liabilities. The following table shows us how different changes in the interest rate assumption will affect the liabilities, and thus, the funding ratio of the Scheme. The following table is based on the March 2018 actuarial valuation.

Change in interest rate basis points	Total Liabilities	Total Assets	Funding Ratio
-200	£103,313,105.21	£74,095,000.00	72%
-175	£97,562,734.11	£74,095,000.00	76%
-150	£92,249,631.86	£74,095,000.00	80%
-125	£87,334,752.83	£74,095,000.00	85%
-100	£82,782,938.04	£74,095,000.00	90%
-75	£78,562,495.38	£74,095,000.00	94%
-50	£74,644,828.23	£74,095,000.00	99%
-25	£71,004,106.60	£74,095,000.00	104%
0	£67,616,975.56	£74,095,000.00	110%
25	£64,462,296.63	£74,095,000.00	115%
50	£61,520,918.09	£74,095,000.00	120%
75	£58,775,470.75	£74,095,000.00	126%
100	£56,210,186.38	£74,095,000.00	132%
125	£53,810,735.88	£74,095,000.00	138%
150	£51,564,085.12	£74,095,000.00	144%
175	£49,458,366.29	£74,095,000.00	150%
200	£47,482,763.02	£74,095,000.00	156%

Table 5: Effect of change in interest rate basis points on the funding level of the Scheme based on the March 2018 actuarial valuation. *Source: WTW internal*

This table shows how the funding ratio would change with fluctuations in the interest rate assumption that are reflected in the calculation of the liabilities. With the current assumption, the Scheme is overfunded with a funding ratio of 110% but we can see that if the interest rate assumption was valued by only 50 basis points less, the funding ratio drops below 100%. This demonstrates the high impact that interest rate assumption can have on the funding level. Interest rates are extremely volatile and for that reason it is important that pension schemes protect themselves against the shocks that can arise from changes in interest rates.

5 Conclusion

We live in an evolving world and DB pension schemes are becoming increasingly unsustainable as well as increasingly relevant. As actuaries, we do our best to project what will happen in the future through methods such as stochastic processing to set assumptions that will give us an accurate prediction of future circumstances. Unfortunately we can never be certain about what will happen in the future.

In the past, DB pension fund managers made promises to their plan members that are difficult to keep in today's economic and demographic environment. For this reason, it is necessary for pension schemes to make the effort to mitigate risks that may have a negative impact on the funding level, especially the most volatile risk, interest rate risk.

Since the financial crisis of 2008 it became even more obvious that pension schemes needed to protect against interest rate risk. Many different strategies were put into place and the investment strategies were reevaluated.

All pension schemes should carefully measure the risks that they are facing and how to mitigate this risks in order to get to a position where they can reliably pay their members. De-risking interest rate risk is a crucial measure that should be put in place to achieve this goal.

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